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(56) Documents Cited
GB 2244189 A **GB 2196211 A** **GB 2112253 A**
EP 0124319 A1 **US 3860872 A**

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UK CL (Edition O) **H4L LDDRS LDDRX LDDSX**
INT CL^6 **H04B 7/08 , H04L 1/06**
ON-LINE : WPI

(54) Mobile Radio Communication System with Diversity Reception

(57) The system comprises a mobile station (2) which carries an antenna (4). This anterna is for transmitting a signal to a base station to which a variety of fixed anterna (6) are connected. The mobile station moves within a predetermined area and transmits signals to the fixed antennas. The fixed anternas provide the base station with the signals they receive. Periodically, the mobile station transmits a known signal. The base station includ s means to determine over a predetermined period of time which of the fixed anternas is receiving the said known signal with the best quality from the mobile station and also includes means to switch reception to one of the fixed antennas in dependence on the result of the determination.

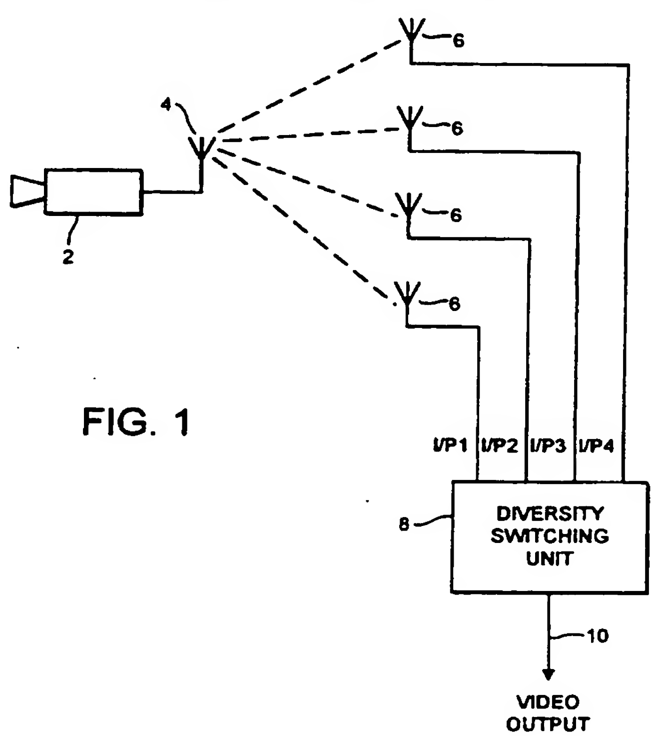

FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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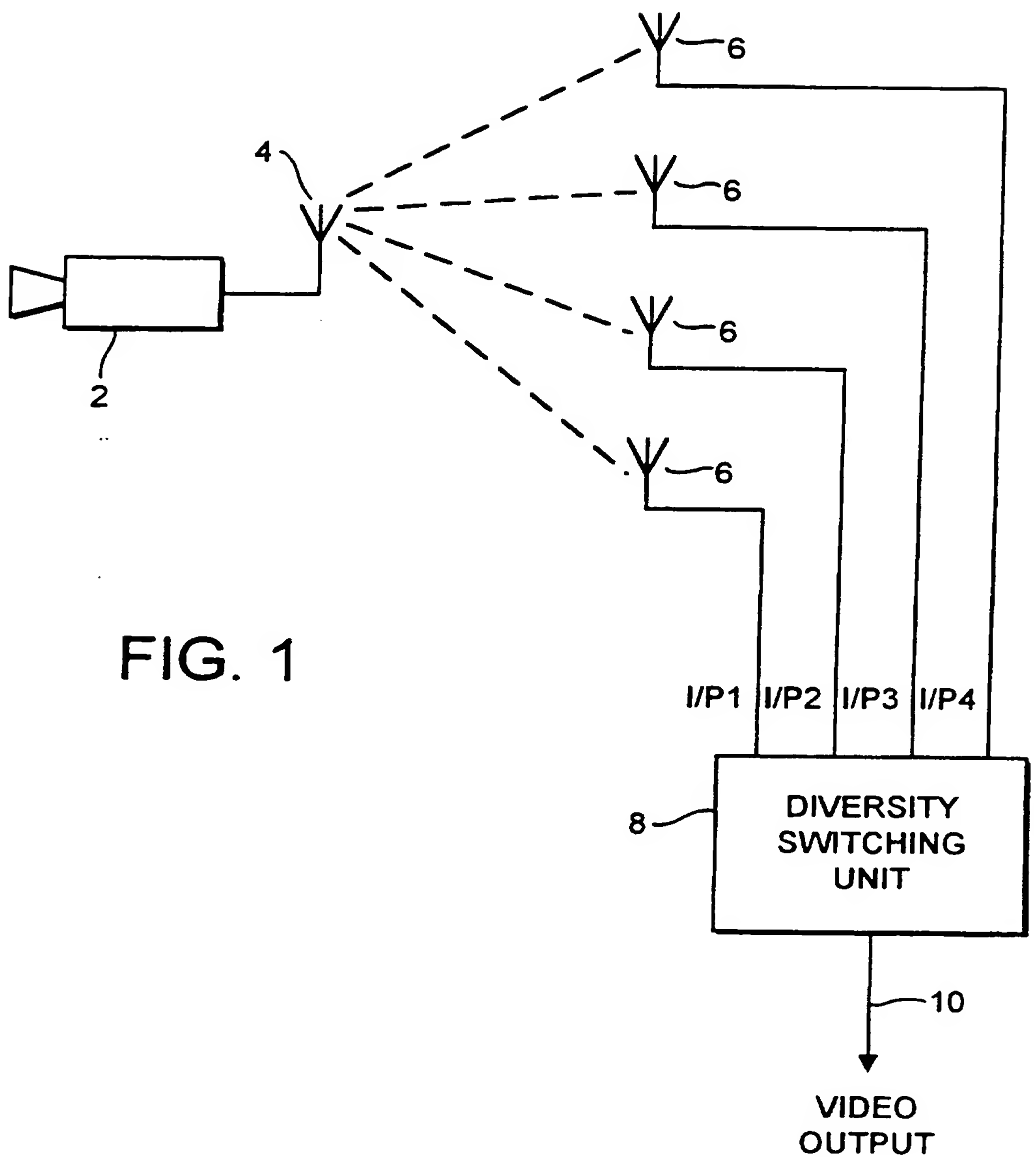

6
4
6
6
6
2
I/P1
I/P2
I/P3
I/P4
8
DIVERSITY
SWITCHING
UNIT
10
VIDEO
OUTPUT

FIG. 1

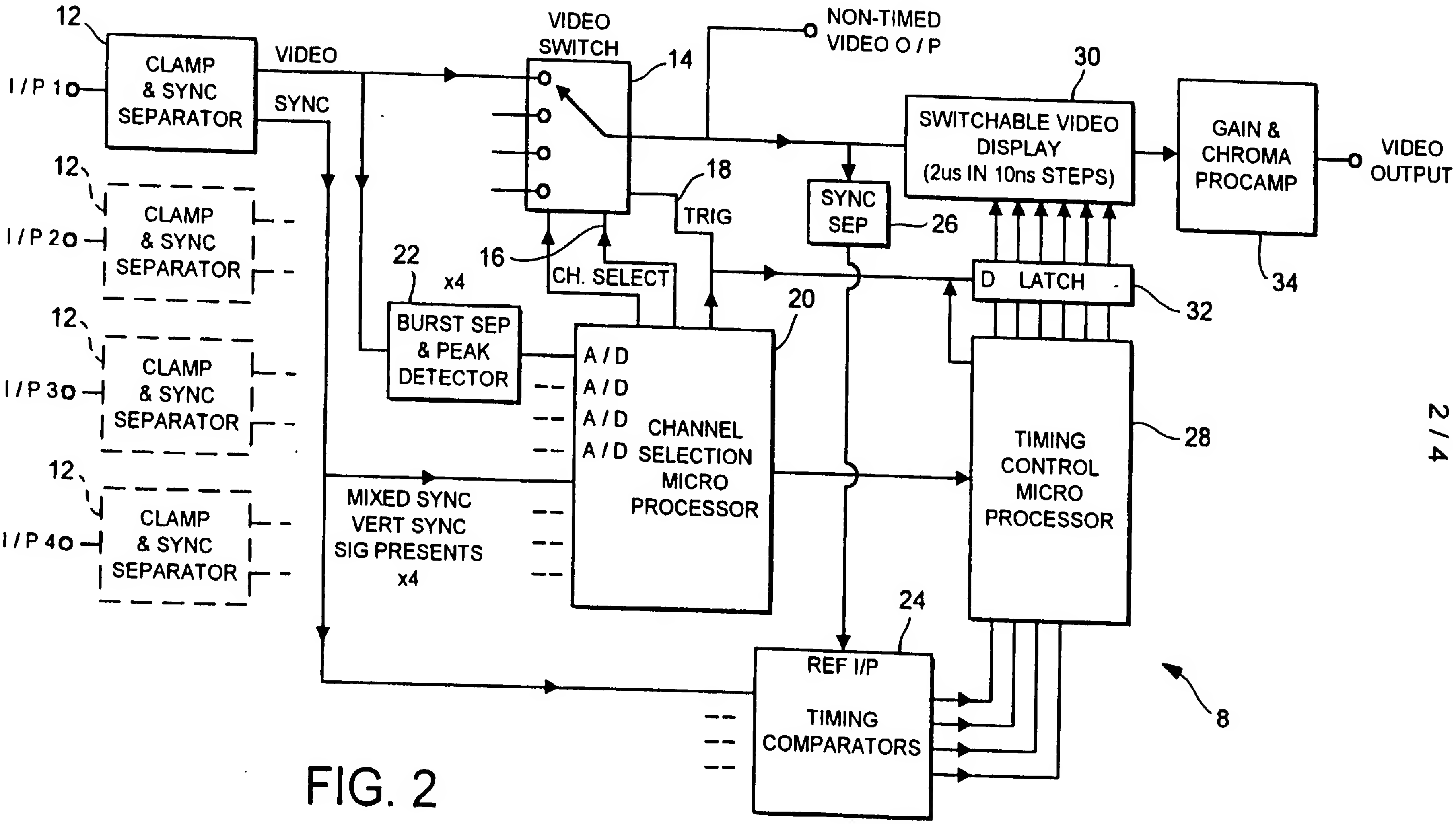
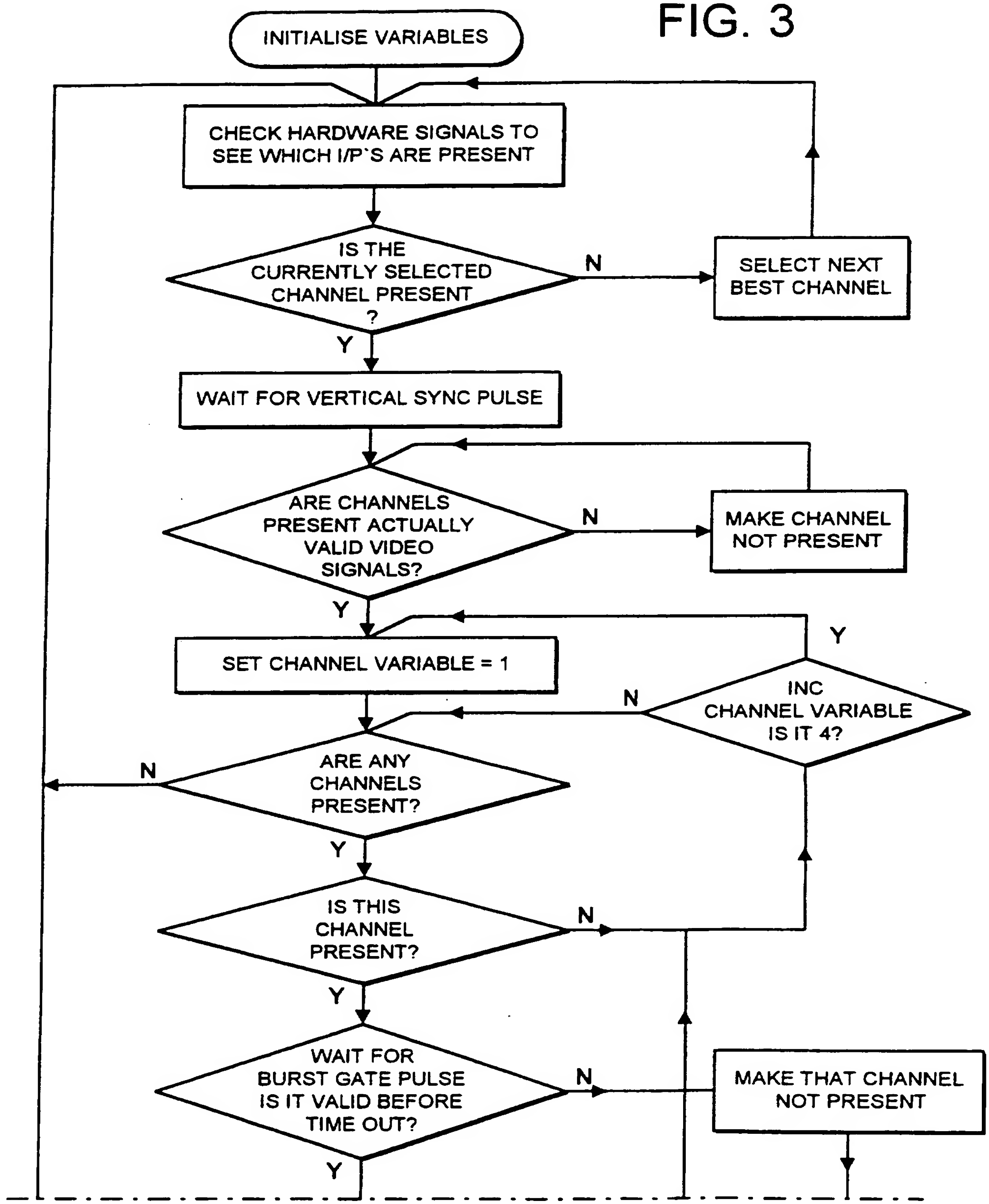

12
I / P 1
CLAMP & SYNC SEPARATOR
I / P 2
CLAMP & SYNC SEPARATOR
I / P 3
CLAMP & SYNC SEPARATOR
I / P 4
CLAMP & SYNC SEPARATOR
VIDEO
SYNC
VIDEO SWITCH
14
16
CH. SELECT
18
TRIG
22
x4
BURST SEP & PEAK DETECTOR
MIXED SYNC VERT SYNC SIG PRESENTS x4
20
A / D
A / D
A / D
A / D
CHANNEL SELECTION MICRO PROCESSOR
NON-TIMED VIDEO O / P
SYNC SEP
26
30
SWITCHABLE VIDEO DISPLAY (2us IN 10ns STEPS)
D LATCH
32
TIMING CONTROL MICRO PROCESSOR
28
24
REF I/P
TIMING COMPARATORS
GAIN & CHROMA PROCAMP
34
VIDEO OUTPUT
8

FIG. 2

FIG. 3


INITIALISE VARIABLES
CHECK HARDWARE SIGNALS TO SEE WHICH I/P'S ARE PRESENT
IS THE CURRENTLY SELECTED CHANNEL PRESENT ?
N
SELECT NEXT BEST CHANNEL
Y
WAIT FOR VERTICAL SYNC PULSE
ARE CHANNELS PRESENT ACTUALLY VALID VIDEO SIGNALS?
N
MAKE CHANNEL NOT PRESENT
Y
SET CHANNEL VARIABLE = 1
Y
N
INC CHANNEL VARIABLE IS IT 4?
N
ARE ANY CHANNELS PRESENT?
Y
IS THIS CHANNEL PRESENT?
N
Y
WAIT FOR BURST GATE PULSE IS IT VALID BEFORE TIME OUT?
N
MAKE THAT CHANNEL NOT PRESENT
Y

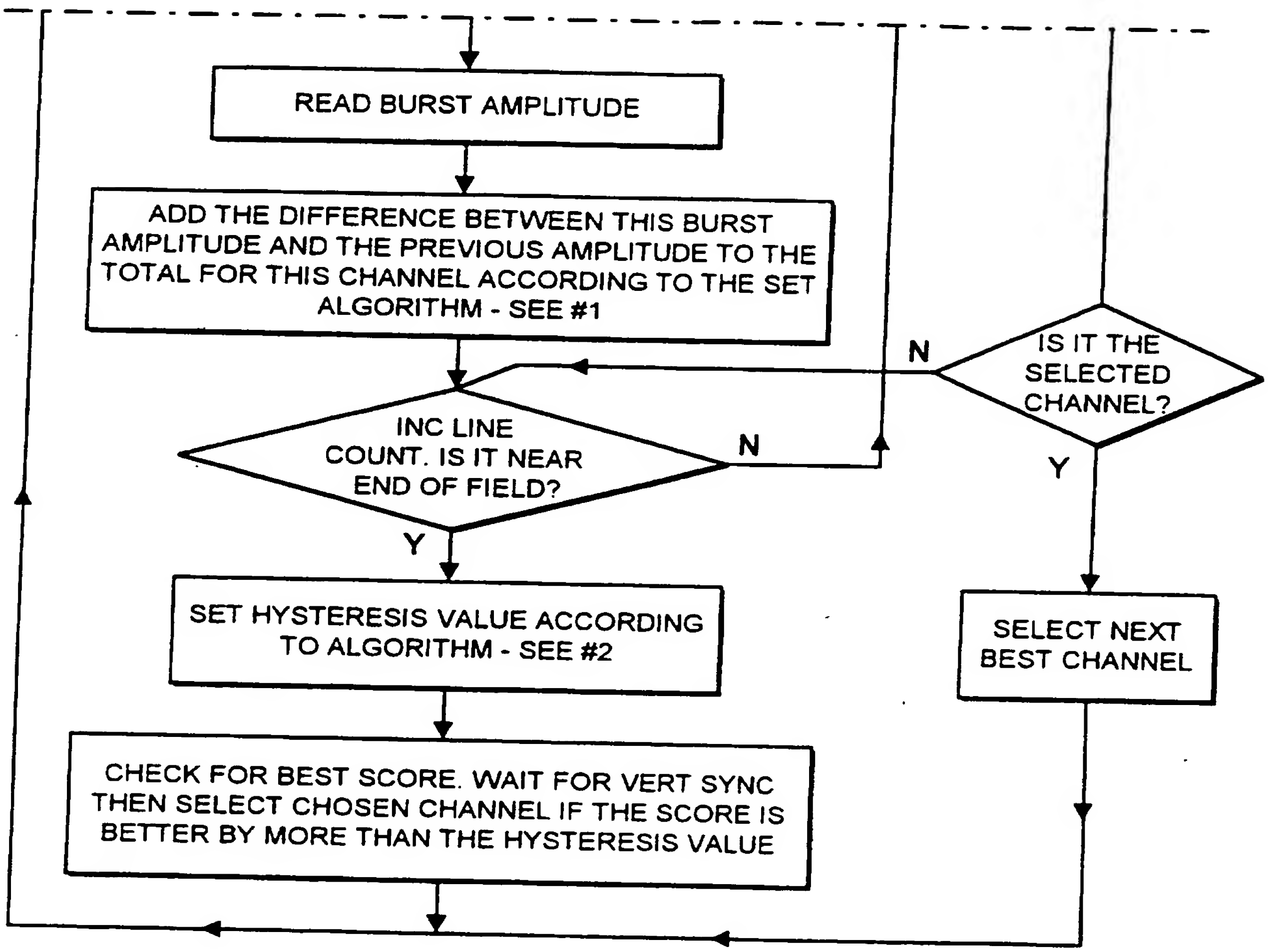

READ BURST AMPLITUDE
ADD THE DIFFERENCE BETWEEN THIS BURST AMPLITUDE AND THE PREVIOUS AMPLITUDE TO THE TOTAL FOR THIS CHANNEL ACCORDING TO THE SET ALGORITHM - SEE #1
N
IS IT THE SELECTED CHANNEL?
INC LINE COUNT. IS IT NEAR END OF FIELD?
N
Y
Y
SET HYSTERESIS VALUE ACCORDING TO ALGORITHM - SEE #2
SELECT NEXT BEST CHANNEL
CHECK FOR BEST SCORE. WAIT FOR VERT SYNC THEN SELECT CHOSEN CHANNEL IF THE SCORE IS BETTER BY MORE THAN THE HYSTERESIS VALUE

FIG. 3 CONT

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DIVERSITY SWITCHING UNIT FOR MOBILE COMMUNICATION LINKS

This invention relates to mobile communication systems and in particular to communication systems of the type which are used with mobile radio cameras or cordless cameras.

Radio cameras or cordless cameras have been developed over a period of years and are used very effectively for television outside broadcasts and also in studios where appropriate.

There are two main problems which have traditionally limited the range and flexibility of radio cameras. These are:

a) multipath propagation caused by reflections from surrounding surfaces, including reflections from the ground and from the ceiling in studios;

b) obstruction of the clear line of sight between the camera and the receiver caused by structural barriers or temporary obstructions such as vehicles and people, including the camera operator.

There are a number of systems in service at the moment all of which concentrate on minimising the effect of multipath distortion. These are summarised below:

1) radio cameras which incorporate directional circular polarised antennas. Signals transmitted from these are received on amanually panned directional antenna which is also circularly polarised;

2) radio cameras of the type described in our British Patent No. GB 2196211. In this the radio camera carries a cluster of directional horn antennas, typically six, grouped together so that their beam widths overlap to give 360° coverage. The system is video based and the

principle of operation is that a test signal is generated in the camera and is transmitted on each of the antennas in turn during a field blanking interval. The receiver analyses the test signal to decide which antenna is giving the best output and relays this information back to the camera so that the appropriate antenna can be used for transmission of the following video field.

3) Ikegami PTR 1 System. This employs an active electromagnetic tracking system to keep a directional antenna in the camera pointing towards a base receiver. The antenna at the base receiver is manually panned and incorporates a transmitter to convey the tracking information back to the camera.

All the above systems operate with a single radio link path between the camera and base reception point for transmission of the video signal and, as already stated, this path can suffer from multipath distortion and from obstruction. Very elaborate methods have been employed to overcome multipath and although these have minimised the problem none have eliminated it completely.

None of the current systems overcome the problem of obstructions between the transmitting antenna and the receiver. One of the most common causes of obstruction is the camera operator himself obstructing the primary transmission path with his own body. Also, none of the current systems provide a solution for the seamless transfer of transmission from one arena of activity to another or one room to another as the mobile camera moves.

Another problem, in particular with the system described in our British Patent No. GB 2196211 is additional weight caused by having a cluster of antennas and the associated switching circuitry mounted on the camera.

We have appreciated that many of the drawbacks of the above systems can be overcome by using a system with several fixed receivers, strategically placed, thereby providing a number of radio link path options. The mobile camera is provided with a broad beamwidth antenna. Signals received at each receiver are assessed for degradation and the receiver giving the best quality signal is selected.

It will be appreciated that the path lengths between the camera and the various receivers will vary as the camera moves. It is therefore necessary to measure the time differences between the inputs and to switch in an adjustable delay to ensure that re-timing of the selected output follows smoothly on from the previous receiver output.

Also, there may be varitions in the signal levels of the demodulated signal and the chroma levels for a video signal. A preferred embodiment of our invention therefore corrects for these.

Preferably, a number of audio channels, typically two, will also be switched along with each video signal.

Because a number of radio link paths are available the receivers can use fixed wide beam antennas, on the basis that at least one of these will be receiving a signal relatively free from multipath distortion at any one time. By the same token, these antennas can be positioned anywhere and as unobtrusively as possible provided that at least one has a clear line of sight to the radio camera at any one time.

A system using this idea should allow radio camera coverage at very complex venues, eg. indoors with the camera moving from one room, down a corridor to another room. A second antenna would be provided to cover each

discrete area and there would be a range such that all the areas overlap. Switching could then provide continous and unterrupted coverage for the entire area.

It will be appreciated that a system such as this requires very little modification to a standard camera and thus the increase in size, weight, and power consumption is minimised.

The invention is defined with more precision in the appended claims to which reference should now be made.

A preferred embodiment of the invention will now be described in detail, by way of example, with reference to the appended drawings in which:

Figure 1 shows a block diagram of a radio camera system emboding the invention;

Figure 2 shows a block diagram of the diversity switching unit of Figure 1; and,

Figure 3 shows a flow diagram of the operation of the diversity switching unit of Figure 2.

Figure 1 shows the total system in which the invention operates. This comprises a mobile and portable radio camera 2 which transmits a video signal representing the scene at which the camera is pointed via a broad beamwidth antenna 4.

A total of, in this example, four broad beamwidth receivering antennas 6 are provided at various points around the area in which the camera is being used. In some situations it will be necessary to have more than four antennas and in others fewer will be required. At least 2 will always be needed for the invention to operate.

The signals received by the four antennas 6 are all fed to a diversity switching unit 8 which monitors the received quality of each signal in turn and then selects

the signal which has been least degraded by multipath distortion and obstruction. This signal is switched to the video output 10 and can then be used as desired. The four inputs to the diversity swiching unit 8 are labelled I/P1 to 4 respectively.

Figure 2 which shows the detail of the diversity switching unit 8 shows the four video inputs I/P1, I/P2, I/P3, and I/P4 from the four antennas. Each input is first fed to a clamp and sync separator 12 which has a video output and a sync output. The sync output comprises the vertical and horizontal synchronising waveforms from each video signal.

The video signals from the clamp and sync separator units 12 form the input to a video switch 14. This is responsive to two channel selection bits 16 and a trigger signal 18 to cause the video switch to select one of the video inputs. The channel selection bits and the trigger signal are both generated by a channel selection microprocessor 20.

The outputs of the clamp and sync separator units 12 are also supplied to four respective burst separator and peak dectector circuits 22. These are responsive to the colour burst transmitted at the start of each line of a field of a video signal to produce an output signal dependent on the peak amplitude of the colour burst. The colour burst is a reference signal used by the automatic gain control circuitry in television receivers to ensure that the signal levels displayed are substantially the same on each line. It is transmitted at the start of each line of the video signal.

The peak signals from each of the burst separator and peak dectectors 22 are all inputs to the channel selection microprocessor 20.

The microprocessor 20 keeps a score or count signal for the variation in burst amplitude for each channel from line to line during a video field. Each signal may be measured on consecutive lines or on every nth line in dependence on the processing power available and the number of receiver inputs being used. At the start of each field the score or count signal for each channel is set to zero. The score for each channel is then compiled by comparing the burst amplitude of a line with the previously measured burst amplitude for a line on the same channel. It could be arranged to measure each burst amplitude for every line but in some circumstances it may be preferable to use alternate lines or every third or fouth line. This will depende on the number of channels being used.

The score for a channel is complied by looking at the burst amplitude for a particular line. If this is, for example, 1% lower than it was on the previously measured line then a count of one is added to the total score for that partiuclar channel. The same score would be added if the burst amplitude was 1% higher. If the difference is 10% then a score of 10 would be added. Thus, by the end of a field the channel selection microprocessor will have built up scores for each channel based on the amount by which the burst amplitudes has varied over that field.

One problem with this approach is that a channel with a steady but low burst level will achieve a similar score to a channel with a steady but correct burst amplitude. Clearly the latter would be the preferable signal to use. To overcome this problem a correction is applied based on the absolute burst level. This is achieved by adding a fixed additional score based on the amount of deviation

from the correct burst amplitude. This again is calculated over the whole field and is then added to the originally complied score. This ensures a channel with good chroma amplitude will always achieve a better score than one with a steady but incorrect chroma amplitude. The exact way in which the score was compiled may be modified in dependence on the exact situation in which the radio camera is being used. Thus in some circumstances a steady but incorrect burst amplitude may still be considered better than a burst which is varying with respect to the correct level.

At the end of each field the channel with the lowest score signal is selected. To prevent rapid switching between similar channels a new channel will only be selected if it is better than the channel currently being used for reception by an amount greater than a hysteresis value which is preset.

The hysteresis value is set in dependence on the lowest channel score from the previous field and on the setting of a user input such as a thumb wheel switch which allows control over the sensitivity of the system.

The best hysteresis setting will be dependent on the lowest score because the score signal will vary according to the number of channels actually present and therefore the itervals between burst measurement for each channel. The more channels there are present the fewer times they will be sampled during a field. For example, the most sensitive setting is based on the lowest score divided by four with a minimum value set at, e.g. 10. The least sensitive value is set by dividing the lowest score by two with a minimum value of 50. This is then compared with the difference between the selected new channel and the

current channel and, if that difference exceeds the hysteresis value the new channel is selected.

As will be seen from Figure 2 the channel selection microprocessor 20 also receives sync. signals from the clamp and sync. separator units 12. These are required to ensure that switching between the four received video signals only occurs in field blanking intervals. Thus, the channel selection microprocessor operates every field blanking interval to generate two channel selection bits corresponding to the channel to be used and a trigger signal to cause the video switch 14 to switch from the current channel to the new channel. This happens when the scoreshave been compiled for each channeland it is indicated that it is necessary to change betweento a different channel for the next video fiel.

The sync signals from the clamp and sync seperator units 12 are also fed to a set of timing comparators 24. The sync signals are compared with the sync signals on the currently selected video signal output by the video switch 14. These signals are extracted from the selected video signal by a sync separator 26. The differences in timing between the currently selected video signal and the four received video signals are then fed to a timing control microprocessor 28. This also receives a signal from the channel selection microprocessor at the end of each field representing the currently selected channel for reception.

The microprocessor 28 generates a set of bits to control a switchable video delay 30 which is provided in the path of the selected video signal. These bits are held on a latch 32. When a new channel is to be selected the channel selection signal from the channel selection microprocessor 20 changes thus causing the output bits of the timing control microprocessor 28 to change to

represent the difference between the selected channel and the channel currently being used. When the trigger signal is generated is by the channel selection microprocessor the set of bits representing the new delay are latched and form the input to the switchable video delay thus altering the delay and causing the newly selected video signal to follow smoothly from the previously selected signal. The switchable video delay is typically a delay of up to two microseconds in steps of ten nanoseconds.

The use of this delay prevents any visible disturbance on the video output signal.

In addition to the above processes the channel selection microprocessor also monitors received signals to determine whether or not an input signal is valid. At the start of every field a simple check is made to determine whether anything is present on each of the inputs. Then, a further careful check lasting four lines per input signal is made to ensure that it is a valid video signal containing sychronising signals and a colour burst and it is not just receiver noise.

Furthermore, simple checks are also made (preferably one per line) to ensure the continued presence of each signal. If at any time the selected signal disappears then the channel selection microprocessor operates to switch immediately to the channel with the next best previously measured score.

When a new channel is selected the switchable video delay 32 is gradually adjusted back towards its mid position by making small (10 nanoseconds) adjustments during each field interval towards the mid position.

Finally, a processing amplifier 34 is provided to correct automatically the video and chroma amplitudes of the selected video signal regardless of the input signal

levels. This effectively removes the need for any further auto correcting devices since the video output will then be substantially constant whichever receiver input is selected. The range of auto control is quite wide being approximately ±6db per video level and chroma level.

The algorithm used to analyse multipath distortion, the hysteresis level, and the sampling times can all be changed to meet specific requirements or adapted to be used with other video formats simply by changing the microprocessors. Alternatively, the unit could be provided preset to operate with a selection of video formats and different algorithms, hysteresis values, and sampling times. The performance of the unit can be monitored by connecting an external PC using a serial data link.

The operation of the Figure 2 can also be understood with reference to the flow diagram of Figure 3. This shows the operation of the circuitry of Figure 2 in a convenient form in the manner discussed above. The tests for presence of any channels, and then for the presence of individual channels during each field are illustrated in this.

It will be appreciated by the skilled man that the above embodiment can be implemented in dedicated hardware or with a combination of hardware and software as illustrated above. The principles described above can be used with any radio link and are not limited to use with radio cameras or to any particular type of radio system or antenna. For example, the receiving antennas used could be designed to give very specific patches of coverage and then arranged so that a number of patches overlap to give continuous uninterrupted coverage. Thus the system would

only switch between antennas as the mobile camera moves from one patch to another.

The system has here been described with reference to the PAL transmission system. However, it could be used with any other transmission system such as NTSC or one of the emerging HDTV and Digital Television formats.

Claims

1. A mobile radio communications system comprising a mobile station carrying an antenna for transmitting a signal to a base station and moving within a predetermined area and a plurality of fixed antennas placed at predetermined positions around the area within which the mobile station moves, the fixed antennas all being coupled to the base station to provide the base station with the signals they receive, the mobile station comprising means to transmit periodocally a known siganl, the receiving station comprising means to determine over a predetermined period of time which of the fixed antennas receives the known signal with the best quality from the mobile unit and means to switch reception for the following period of time to one of the antennas in dependence on the result of the determination.

2. A mobile radio communications system according to claim 1 in which the determining means at the fixed station measures the quality of the received known signal by determining its total variation in amplitude over the predetermined period of time.

3. A mobile radio communications system according to claim 2 in which the determining means also compares the amplitude of the recieved known signal with the known amplitude of that signal.

4. A mobile radio communications system according to any preceding claim in which the switching means only operates to select a different antenna to the one currently

selected when the quality of the known signal received by one of the antennas exceeds that of the currently selected antenna by a predetermined amount.

5. A mobile radio communications siganl according to any preceding claim in which the mobile station comprises a television camera and the known signal comprises a portion of the video signal produced by the camera.

6. A mobile radio communications system according to claim 5 in which the known signal comprise the colour burst signal provided in each line blanking interval of the video signal.

7. A mobile radio communications system according to claim 5 or 6 in which the predetermined period of time comprises a video field period.

8. A mobile radio communications system substantially as herein described with reference to the accompanying drawings.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)** 14	Application number GB 9523700.4
Relevant Technical Fields (i) UK Cl (Ed.O) H4L (LDDSX, LDDRS, LDDRX) (ii) Int Cl (Ed.6) H04B (7/08) H04L (1/06)	Search Examiner P S DERRY Date of completion of Search 22 JANUARY 1996
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-7

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2244189 A	(ORBITEL) see especially page 6 and page 13, lines 18 to 22	1
Y	GB 2196211 A	(BBC) see whole document	1, 2, 5, 7
Y	GB 2112253 A	(SUNDSTRAND) see especially page 2, lines 14 to 18	1
Y	EP 0124319 A1	(AT&T) see page 5, line 24 to page 6, line 34	1
Y	US 3860872	(RICHARDSON) see especially the Abstract	1, 2, 5, 7

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